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LARS Information Note 052975

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(NASA-CR-144396) THE FOCUS SERIES 1975: A COLLECTION OF SINGLE-CONCEPT REMOTE SENSING EDUCATIONAL MATERIALS (Purdue Univ.) 47 p HC $3.75 CSCL 08B

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THE FOCUS SERIES 1975: A COLLECTION OF SINGLE-CONCEPT REMOTE SENSING EDUCATIONAL MATERIALS

SHIRLEY M. DAVIS

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The Laboratory for Applications of Remote Sensing

Purdue University, West Lafayette, Indiana

1975

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The FOCUS Series 1975: A Collection of Single-Concept Remote Sensing Educational Materials

by
Shirley M. Davis

Abstract

The Focus Series has been developed to present basic remote sensing concepts in a simple, concise way. Issues currently available are collected here so that more people may know of their existance.

Recent technological developments in remote sensing and the broadening of its use have quickly caused much of the existing educational material in remote sensing to be outdated. Today only a very small body of current, instructional materials on the subject is available commercially, and there is, as yet, no fully-integrated remote sensing textbook. While a person entering the field can readily find numerous technical research reports, he may have considerable difficulty locating materials which describe the concepts basic to remote sensing technology as it is developing today.

In recognition of this need, the FOCUS series is being developed as a way to explain and illustrate basic remote sensing concepts. Each pamphlet in the series is designed to

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The FOCUS Series was developed under NASA Contract NAS 9-14016 and Grant NGL 15-005-112. S.M. Davis is Training Specialist at the Laboratory for Applications of Remote Sensing, Purdue University.

illuminate a single concept through one page of concisely written text supported by illustrations. Extensive care is taken to minimize the use of technical terms in the descriptions and to include definitions where confusion might occur.

The FOCUS issues on "Remote Sensing," "The Multispectral Scanner," and "LANDSAT" require no prior understanding of remote sensing; the ones on "Pattern Recognition" and "Sample Classification" assume that the reader has at least a minimal understanding of the nature of remote sensing data. Several other issues in the FOCUS series describe applications of remote sensing: "Cover Type Classification," "Mapping Soil Characteristics," and "Crop Species Identification."

The educational aim of the series has affected its design in a number of ways. The format of the pamphlets was designed so that they could be both relatively inexpensive to produce and yet attractive to the potential reader. Secondly, each issue contains a list of suggestions for further reading to guide a student wishing to pursue the topic in greater depth. In preparing these bibliographies, authors give preference to titles which are available in the open literature.

The challenge in preparing a FOCUS issue is to present a complex topic in such a way that it is neither unnecessarily complicated nor in any way misleading to the reader who has no prior understanding of the concept. In order to insure that this requirement is met, each FOCUS issue is subjected to rigorous in-house review by a variety of people: remote sensing specialists, technicians, educationalists, communicators, engineers and scientists.

Purposely designed to be brief, individual titles in the FOCUS series do not lend themselves to being submitted as technical reports. In order that more people may know of their existance and the rationale behind them, the titles which currently exist are being collected as a part of this Information Note.

Acknowledgments

The author wishes to acknowledge the contributions of several LARS' staff members to the present series: to Roger M. Hoffer and John C. Lindenlaub, who identified the need for materials such as these; and to those who have participated in their development: Tina K. Cary, John C. Lindenlaub, Douglas B. Morrison, Terry L. Phillips, Barbra J. Pratt, James D. Russell, Philip H. Swain, and Leslie Wilson.

Titles Available

July, 1975

"The Multispectral Scanner"
"Cover Type Classification"
"Pattern Recognition"
"Mapping Soil Characteristics"
"Sample Classification"
"Earth Resources Data Processing System"
"Remote Sensing"
"LANDSAT: An Earth Resources Data Collection System"
"Role of Images in Numerical Data Analysis"
"Crop Species Identification"
"What is LARSYS?"

LARS - Purdue 1973

Number 1

THE MULTISPECTRAL SCANNER

The Multispectral Scanner

There are many types of sensor systems that can be used in remote sensing. Photographic systems are the most common, but since photographic films are sensitive to energy only from a limited portion of the electromagnetic spectrum (visible and near-infrared wavelengths), they cannot obtain information about the thermal characteristics (temperature and emissivity) of the vegetation, soil, and water on the earth's surface. Scanners sensitive to energy in only the thermal region can accomplish this, but multispectral, optical-mechanical scanners are capable of collecting data in the visible and thermal portions of the spectrum (0.3-15.0 μm). They are usually mounted on aerospace platforms, either aircraft or satellite.

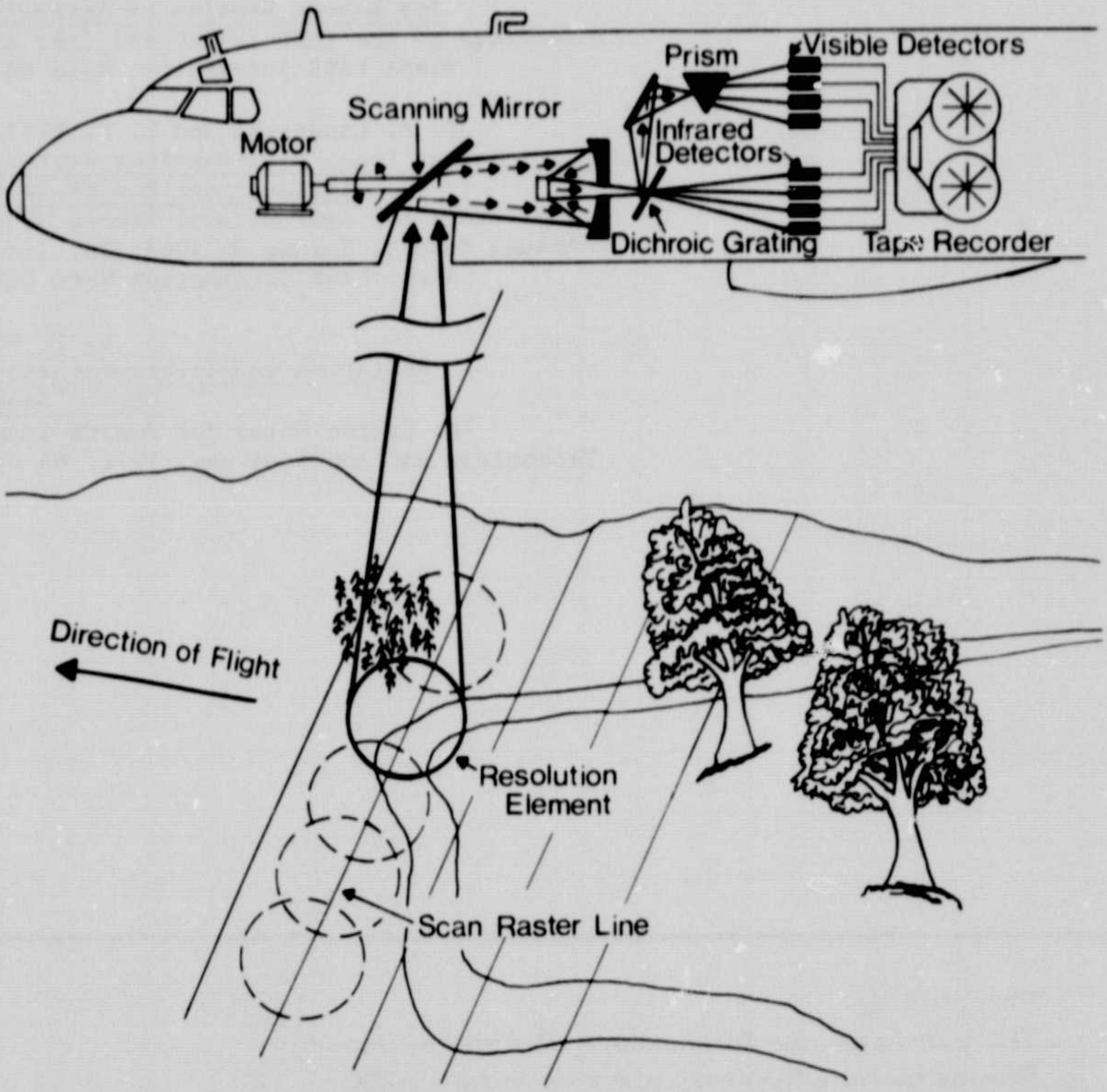
Opposite is a diagram of a typical multispectral, optical-mechanical scanner. The energy reflected and emitted from a small area of the earth's surface is "seen" by the scanning mirror, then is reflected through a system of optics where it is spectrally dispersed. In this example the energy in the visible wavelengths (.38-.72 μm) is spread by a quartz prism; dichroic gratings are used as dispersive devices for the infrared energy (.72-14.0 μm). The detectors, carefully selected for their sensitivity in the various portions of the spectrum, measure the energy in specific wavelength bands. The size of the resolution element, the instantaneous field of view of the scanner, is a function of the scanner configuration and the altitude of the platform.

As the platform passes over an area, the ground surface is scanned in successive strips, or scan lines, by the mirror. While the rotating motion of this mirror allows the energy along a scan line to be measured, the forward movement of the platform, which is perpendicular to the scan line, brings successive strips of terrain into view. Thus, when parameters of the data-gathering system have the proper relationship, a continuous area of the earth's surface can be sensed using several wavelengths bands which can encompass the entire optical portion of the electromagnetic spectrum.

The output signals from the detectors are amplified and then simultaneously recorded on magnetic tape or transmitted directly to the ground. An important feature of this sensing system is that sampling the output of all bands produces single data sets containing all the spectral information available for a given resolution element. This is a convenient way to pack the data for machine processing.

While photographic data collection systems tend to retain better spatial accuracy, optical-mechanical scanner data have better spectral resolution since the parameters of the detectors can be set for much narrower wavelength bands and there is inherent registration between spectral channels. Data reformatting, calibration, and registration need to be performed before the data is ready for analysis.

(smd)



Prism
Visible Detectors
Scanning Mirror
Motor
Infrared Detectors
Dichroic Grating
Tape Recorder
Direction of Flight
Resolution Element
Scan Raster Line

FURTHER READING

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A Multichannel Image Data Handling System for Agricultural Remote Sensing
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Prepared by
The Laboratory for Applications of Remote Sensing
Purdue University, West Lafayette, Indiana 47907

S. M. Davis, General Editor

LARS - Purdue 1973

Number 2

COVER TYPE CLASSIFICATION

Cover Type Classification

In many ecological and agricultural situations there is a need to map various cover types over large geographic areas in a relatively short period of time. The computer-aided classification of data gathered by multispectral, optical-mechanical scanners aboard aircraft or spacecraft can meet this need. It is the differences which exist between the spectral signatures of materials that make this automatic identification possible.

The accompanying illustration shows the results of a computer-aided classification of multispectral data into vegetation, bare soil, and water for an area of central Indiana. The aerial photography on the left, taken ten days before the scanner data were collected, serves as a point of comparison for the accompanying computer printouts.

First, multispectral scanner data were collected from an altitude of 3,200 feet. These data are measurements of reflected energy in specific wavelength bands for each resolution element, or area on the ground viewed in any one instant -- in this case an area of about nine square yards.

The key to the computer-aided analysis of data lies in pattern recognition. In the analysis discussed here, measurements for areas where the cover type was known provided the basis for "training" the pattern recognition categorizer to recognize similar measurements in unidentified areas.

After the three wavelength bands or channels most effective for doing the classification were selected, the processor compared the response pattern of each unidentified resolution element in each of these channels with the measurements for each known cover type and automatically assigned that resolution element to the class it most closely resembled.

The lefthand printout below is a visual representation of the results of the classification. The computer printed an "M" for all areas identified automatically as water; they appear as a dark tone on the printout. Bare soil areas were printed with dashes (light-toned areas), and green vegetation was identified by "I" (intermediate tone).

At the right is a printout showing just those areas identified as water. Many of the areas appear rather small and scattered; they are actually ponded areas and water in drainage ditches. It is interesting to note that the computer-aided classification resulted in correct identification of water in several locations which had previously been overlooked on the aerial photographs. Overhanging tree branches or indistinctive color differences between the water and the surrounding materials obscured the water from visible detection; differences in reflectance characteristics in the scanner imagery, however, made the identification possible.

Checking the classification accuracy in 107 randomly selected sample areas revealed that the average accuracy was 99.4% for green vegetation, 98.0% for soil, and 96.7% for water.

(end)

Photograph

Computer Printout of
Green Vegetation, Soil,
and Water

Computer Printout
of Water Only

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Prepared by
The Laboratory for Applications of Remote Sensing
Purdue University, West Lafayette, Indiana 47907

S. M. Davis, General Editor

LARS-Purdue 1973

Number 3

PATTERN RECOGNITION

The Role of Pattern Recognition

Pattern recognition can be used as a basis for machine-aided analysis of remotely sensed data. A block diagram of a pattern recognition system is shown in Figure 1. In the LARS context the receptor or sensor which observes "patterns" is a multispectral scanner, and its output is a set of reflectance measurements for an individual resolution element or area of the ground. In the case of the Earth Resources Technology Satellite (ERTS-1), for example, a set consists of measurements of irradiance in four spectral bands (.5-.6, .6-.7, .7-.8, .8-1.1 μm) and may be represented as a four-component vector, $X = (x_1, x_2, x_3, x_4)$.

The decision maker reads the measurement levels from the receptor and classifies the resolution element into one of several possible classes. This classification can be made by various techniques, but in all cases information about the possible classes must previously have been supplied to the decision maker. In practice this information is obtained from training samples.

As a simple example, suppose an area consisting of soil, vegetation, and water is to be classified. Assume that the receptor makes two measurements on each resolution element, i.e., $X = (x_1, x_2)$. To acquire a set of training samples for each class, a set of observations of areas known to be water, vegetation, and soil respectively is obtained. For the observations belonging to each class, the mean or average values for the two measurements, x_1 and x_2, are computed and "decision regions" established (Figure 2). The decision maker can now classify the entire area: when given the measurements for a resolution element of unknown classification, it assigns that element to the class with the closest mean vector. In Figure 2 the unclassified element "U" would be classified as vegetation.

The example uses a very simple method of classification. For improved accuracy, LARS uses techniques which consider not only the means of the training samples but also their variances.

Pattern recognition is especially suited for handling large quantities of data with minimal human involvement. It provides an automatic procedure for decision making which is readily implemented on high-speed data processing equipment.

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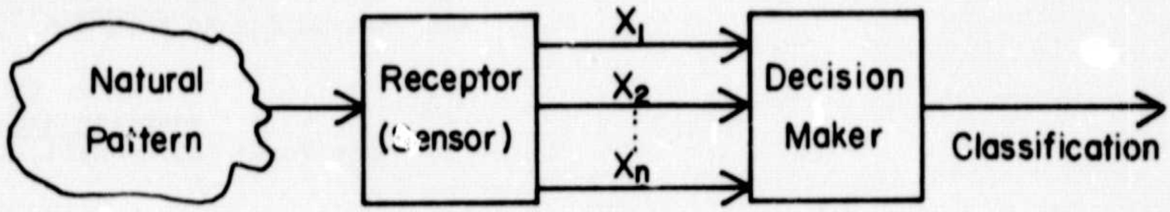

Figure 1. A Pattern Recognition System

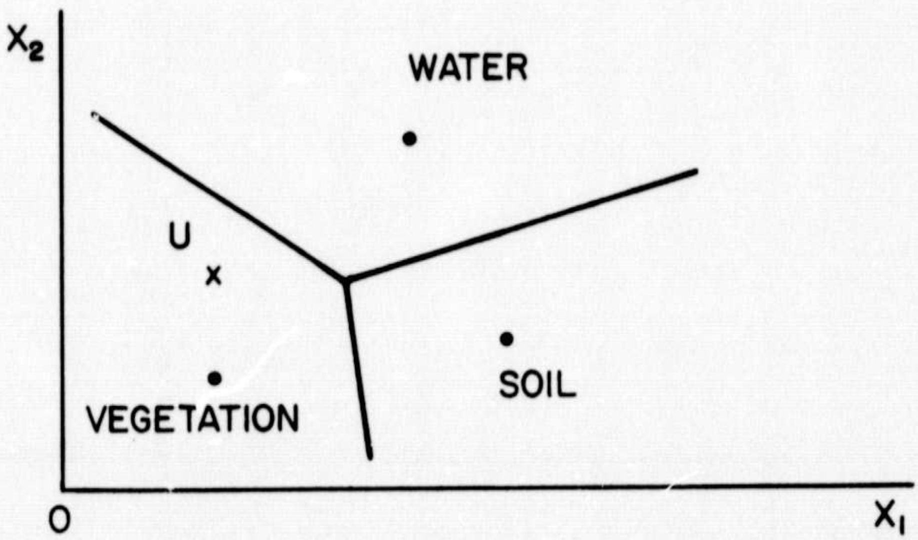

Figure 2. Class Means and Decision Regions

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Prepared by
The Laboratory for Applications of Remote Sensing
Purdue University, West Lafayette, Indiana 47907

S. M. Davis, General Editor

LARS - Purdue

MAPPING SOIL CHARACTERISTICS

Mapping Soil Characteristics

Over the years soil scientists have defined meaningful soil categories based primarily on such features as soil texture, parent material, slope, and drainage characteristics. Each year the soils on over 50 million acres of the United States are mapped into these categories by the Soil Conservation Service and other agencies as an aid to the nation's resource management. Conventional mapping techniques involve field mapping with use of black and white aerial photos as map bases. A number of new techniques are being investigated in an effort to accelerate the entire soil mapping program.

Within the past decade, advances in airborne and spaceborne sensor systems have made it possible to obtain vast quantities of spectral reflectance data over large geographic areas in a very short time. Such data-acquisition systems, when coupled with computer-aided analysis, offer the soil scientist another tool for surveying soil characteristics. Gridding and sampling techniques make it possible to correlate precise locations of soil samples with known addresses on the magnetic tapes containing scanner data.

The figure opposite represents one type of soil mapping that can be done by analyzing multispectral scanner data using LARSYS, the computer software system developed at Purdue University specifically for analysis of this data. On the left is a soil survey map of a nearly level area in Tippecanoe County, Indiana. The map was made by conventional field mapping procedures. The computer printout on the right is a visual representation of a classification of the scanner data collected when the soil surface was bare. On the basis of the multispectral reflectance characteristics, it was possible for the soil scientist to discriminate reasonably well between several of the soils types.

The usefulness of reflectance data for soil mapping is limited by the fact that conventional soil series are differentiated by both surface and subsurface properties; hence, a technique dependent on surface distinctions would not discriminate between soils which themselves are differentiated by subsurface features only. Greatest success in soil mapping has been achieved when variations in spectral response <u>within</u> a soil type are smaller than the variations <u>between</u> soil types.

Maps delineating other soil characteristics such as organic matter content and internal drainage patterns have also been produced using computer-aided analysis of multispectral reflectance data. The production of soil-characteristic maps by this method depends primarily on the degree of correlation between the spectral properties of the soils and the significant physical and chemical soil properties. Soil color has a major influence on the reflectance, but variations in soil moisture and in the surface condition (roughness, crusting or cultural practices) also modify the reflectance; crusted soils have a higher reflectance value than rough, and dry higher than wet.

For the soil scientist, the promise of computer-aided analysis of reflectance data lies not so much in achieving a one-to-one relationship with the categories of the traditional soil surveys as in determining broad soil characteristics and soil patterns over wide areas in a short time. There is adequate evidence that reflectance data gathered at satellite altitudes can also be an effective tool for use in soil mapping programs particularly when less detail is desired, as in reconnaissance soil surveys.

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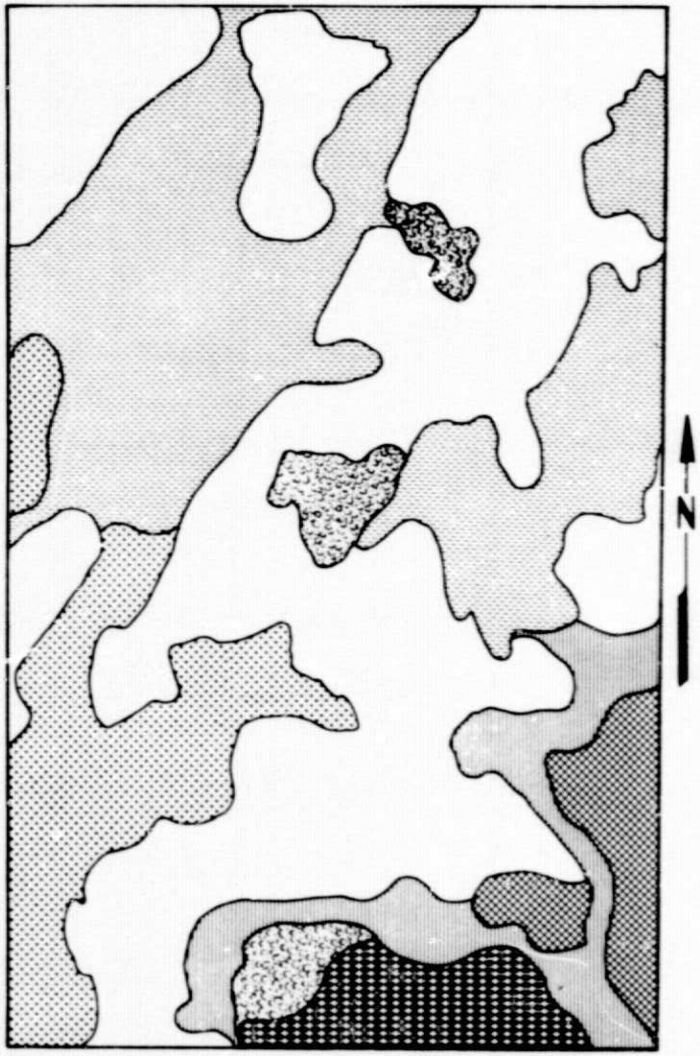
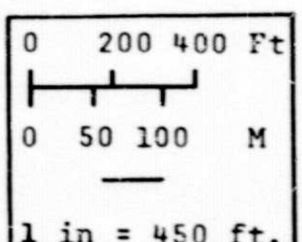
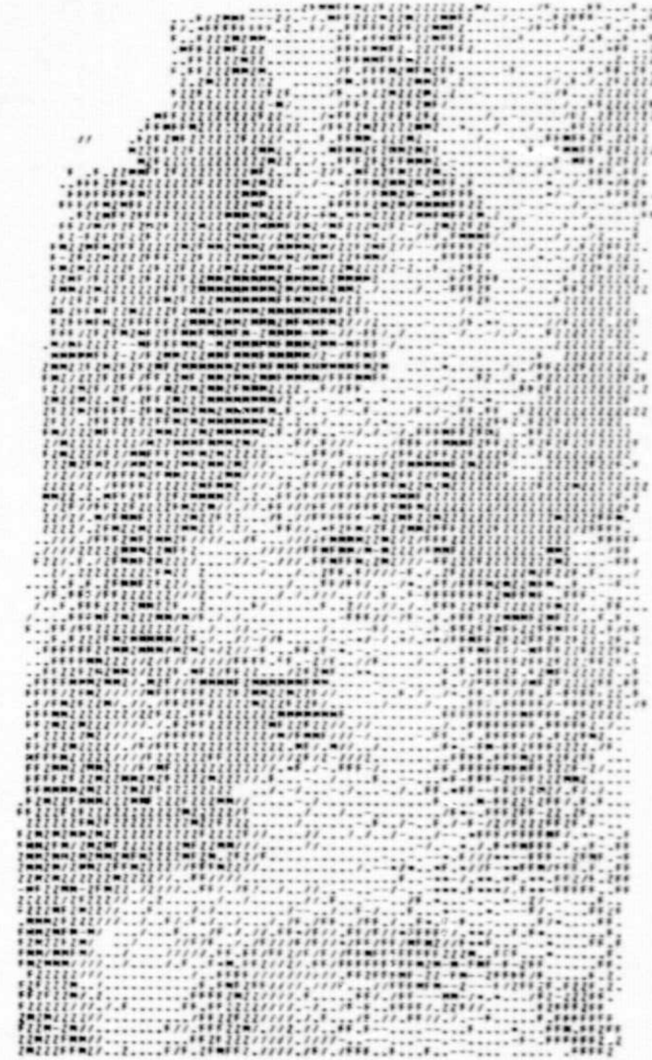


Ragsdale silty clay loam
Brookston silty clay loam
Brookston silt loam
Toronto silt loam
Crosby silt loam
Celina silt loam
Reesville silt loam





M Ragsdale silty clay loam
Z Brookston silty clay loam
F Brookston silt loam
/ Toronto silt loam
- Crosby silt loam
= Celina silt loam
· Reesville silt loam

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Prepared by
The Laboratory for Applications of Remote Sensing
Purdue University, West Lafayette, Indiana 47907

S. M. Davis, General Editor

LARS - Purdue

SAMPLE CLASSIFICATION

Sample Classification

A *sample* is a collection of data points, perhaps from a remote sensing data set. In *sample classification*, a collection of data points, all assumed to be members of the same class, are classified as a group, i.e., simultaneously and into the same class. The reader may be more familiar with the operation of point classification in which, by contrast, data points are always classified one at a time (Figure 1).

In sample classification, we compute the "distance" from the data points comprising the sample to the training samples (representative data points) for the classes of interest and assign all of the points in the sample to the nearest class. The "distances" which must be computed involve the statistical distributions of the data in the unknown sample and the training samples. They are considerably more complicated than simple point-to-point distances. The details, beyond the scope of this article, may be found in the suggested Further Reading (see the back cover).

Why use sample classification for analyzing remote sensing data? The answer to this question can be derived from the observation that the group of data points (the sample) contains more information than any one of the data points. As with the training samples, both the location of the points and how much they tend to differ from each other provide information about which class they belong to. Another reason for using sample classification is that it may be more economical computationally to classify samples than to classify the data points individually. This depends to a large extent on the size of the samples.

To be useful in practice it is necessary that the computer be able to automatically select the samples to be classified. Algorithms have been developed which can accomplish this quite effectively for agricultural remote sensing data, in which case the samples are usually agricultural fields -- hence the term "per-field classification" is sometimes used. Figure 2 shows an example in which the field boundaries have been located and drawn by the computer.

Figure 3 shows a comparison of classification accuracies achieved by point classification and sample classification for the same set of data. These results are typical. They illustrate the improved classification accuracy which can often be achieved by using sample classification.

Prepared by Philip H. Swain

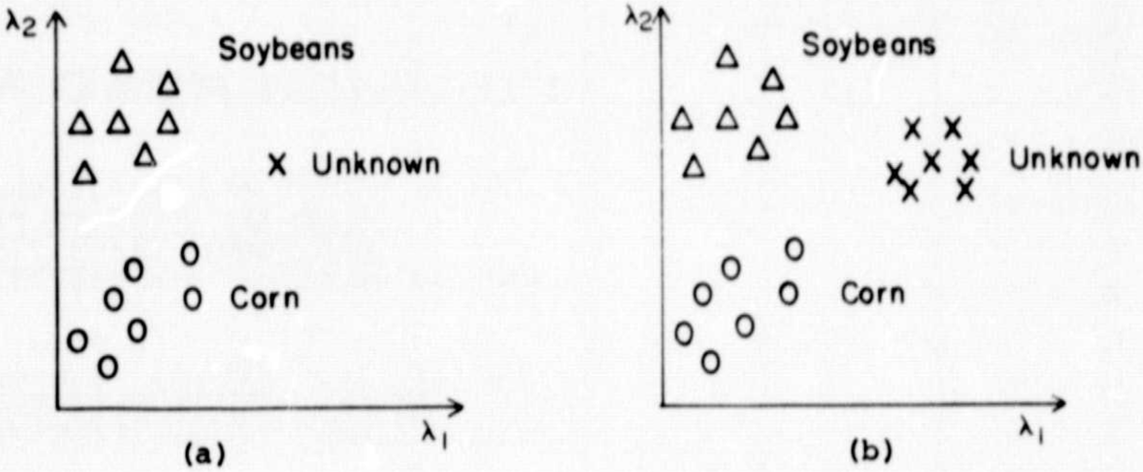

Figure 1. Point classification (a) vs. sample classification (b).

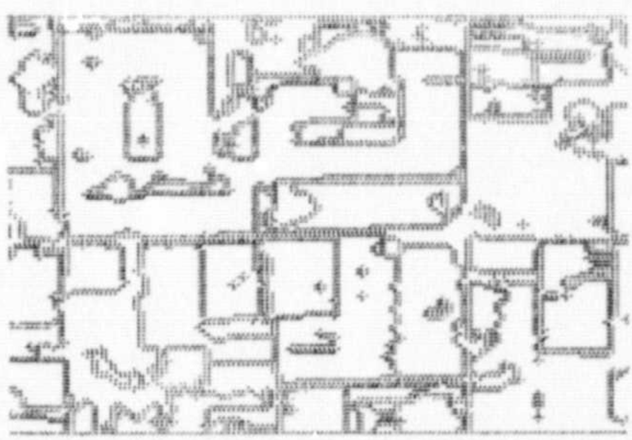

Figure 2. Computer-drawn boundaries

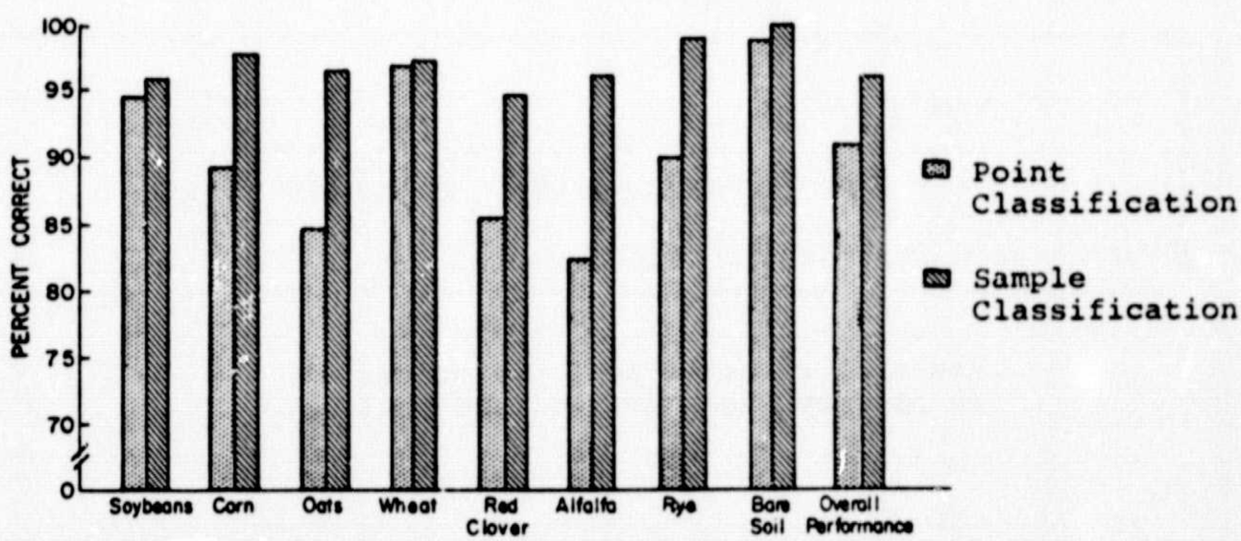

Figure 3. Comparison of point classification and sample classification results.

FURTHER READING

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P. H. Swain
<u>Pattern Recognition: A Basis for Remote Sensing Data Analysis</u>
LARS Information Note 111572. 1972

Also see a related title in this series:
FOCUS: Pattern Recognition

Prepared by
The Laboratory for Applications of Remote Sensing
Purdue University, West Lafayette, Indiana 47907

S. M. Davis, General Editor

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75-2

LARS - Purdue

Earth Resources Data Processing System

Earth Resources Data Processing System

The Laboratory for Applications of Remote Sensing at Purdue University (Purdue/LARS) has developed an Earth Resources Data Processing System which is being used by a dispersed community of remote sensing scientists (see map).

The facility consists of the LARSYS software system, a multispectral data bank and a general purpose computer. LARSYS is a fully-documented, multi-image data analysis software system designed to provide for advanced research, development, and applications of remote sensing concepts and systems. The multispectral data bank, a collection of data acquired above the earth's surface via aircraft and satellite scanners recording radiation levels in selected portions of the electromagnetic spectrum, is available to all users of the Earth Resources Data Processing System and serves as its primary data base. The implementation of LARSYS on a general purpose computer with time sharing and remote terminal capabilities increases the system's value to the large group of users.

The resulting Earth Resources Data Processing System provides: 1) full user access, at the user's location, to both the data and the processing capability; 2) centralization and sharing of the expensive hardware or computer equipment at considerable cost advantage; 3) centralization of programming or software maintenance, with additional cost advantage and updating flexibility; 4) ease of training users; and 5) the opportunity of sharing results through standard data formats, terminology and simplicity of communication.

Prepared by B. J. Pratt

PURDUE/LARS Computer Center

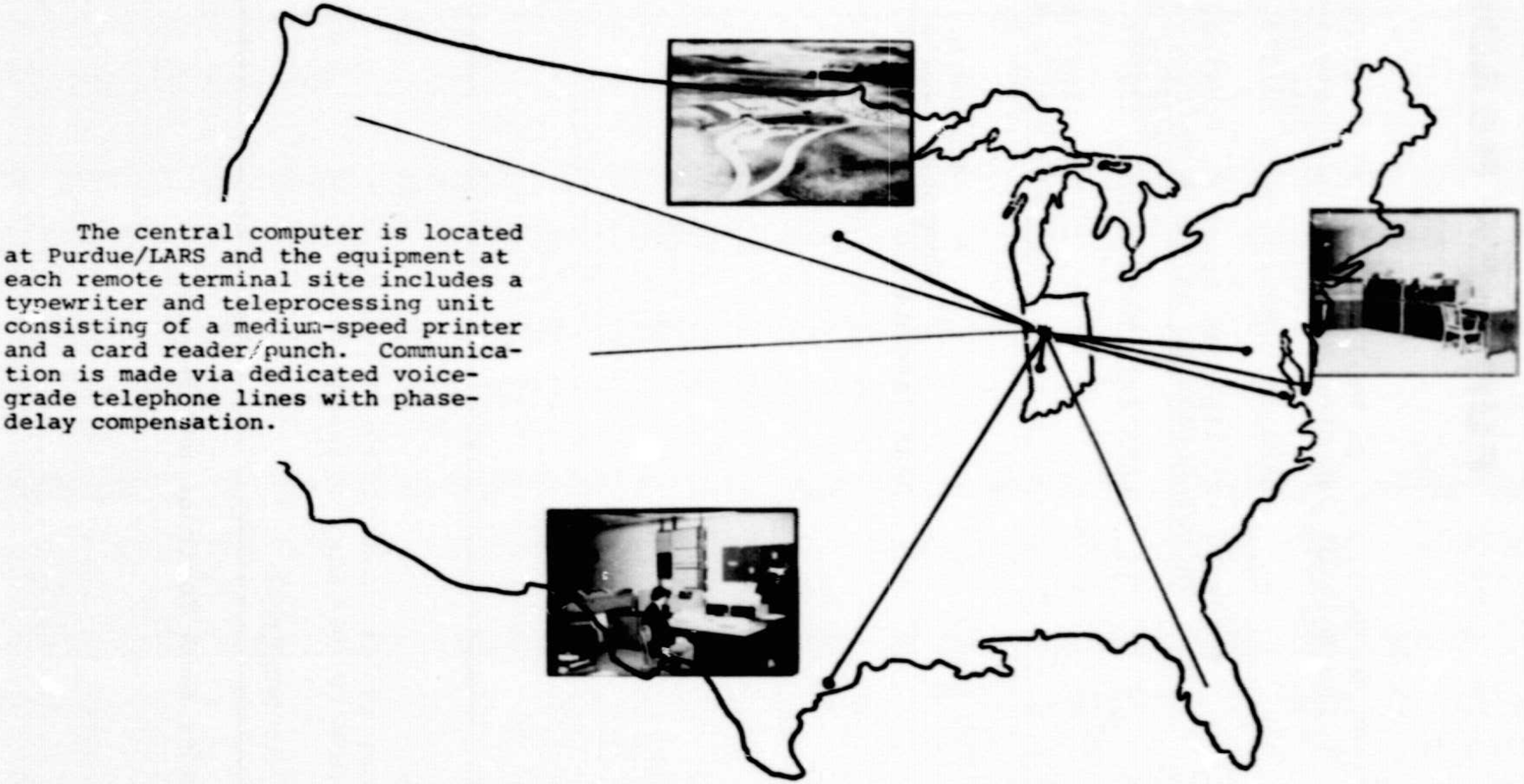

Figure 1. Earth Resources Data Processing Network

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Prepared by
The Laboratory for Applications of Remote Sensing
Purdue University, West Lafayette, Indiana 47907

S. M. Davis, General Editor

Prepared under NASA Contract NAS 9-14016

LARS - Purdue

REMOTE SENSING

REMOTE SENSING

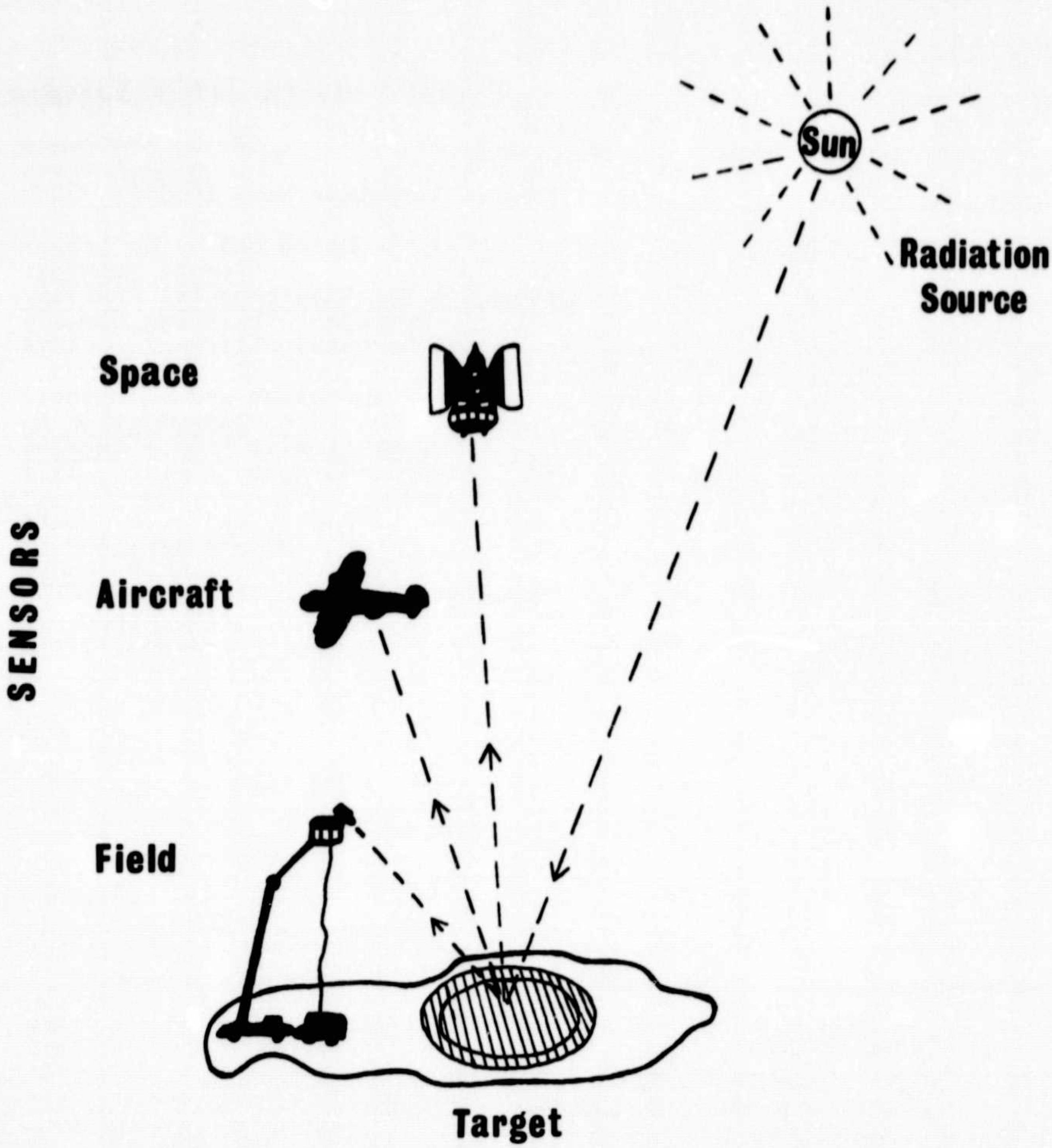
> Remote sensing is the science of acquiring information about distant objects from measurements made without coming into contact with the objects.

This is a technical definition of remote sensing. Let's look at some familiar examples of remote sensing instruments, such as your eye. You can see the moon, but certainly there is no way you can touch the moon -- unless you are an astronaut. A camera is another example. It can "acquire information" about objects, people, and landscape scenes without actually touching them. In fact cameras are widely used in remote sensing.

The figure shows three types of remote sensing data collection systems. The sensor, which may be a camera or other energy-measuring instrument, is aimed at a target or scene on earth. The sensor measures and records the energy reflected or emitted from objects on earth. Different objects radiate different kinds and amounts of energy -- in our camera analogy, different colors. The different colors, sizes, locations and changes over time which characterize the objects can be recorded by a remote sensing system. As in the diagram, the sun is often the primary source of the energy. Some remote sensing systems, such as laser and radar systems, use energy sources other than the sun. These two types of systems are often referred to as active systems. Returning to our camera analogy, when you take a picture outside during the day, the sun is the energy source and the camera is a passive sensor, i.e., using an external energy source. However, if you want to take a picture at night, you must use a flashbulb or other energy source in conjunction with the camera. The camera then provides its own light source and is an active remote sensing system.

The applications of this new technology are very diverse and continue to grow rapidly. Agricultural applications include identification and mapping of crop species; the value of this information is substantial in today's world with its increasing demand for food. Remote sensing can also be used to distinguish the types of trees in a forest and identify areas of trees that are diseased. Land-use maps, helpful in urban planning, can be produced from remote sensing data. Remote sensing has also been used for detecting pollution, studying environmental problems, exploring for mineral resources and assessing rapidly the damage of natural disasters.

Prepared by James D. Russell



Radiation from the sun is reflected or emitted by the target or scene on the earth and then detected by remote sensing instruments. These instruments may be in field-based trucks, on aircraft or aboard satellites.

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Purdue University, West Lafayette, Indiana 47907

S. M. Davis, General Editor

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LARS - Purdue

LANDSAT: An Earth Resources Data Collection System

LANDSAT: An Earth Resources Data Collection System

In July 1972, the National Aeronautics and Space Administration launched the first Earth Resources Technology Satellite, originally called ERTS-1, to collect information about the surface of the earth from hundreds of miles above it. In February 1975, a second satellite in the series was launched to continue this data-collection task. At about the same time, the satellites were renamed LANDSAT.

To collect data over as much of the earth as possible, the LANDSAT satellites follow a polar orbit at an altitude of 920 km (570 miles). Circling the globe every 103 minutes (14 times a day), each satellite has an 18-day cycle, which means all portions of the earth are covered every 18 days. Thus, changes occurring on the earth can be monitored on 18-day intervals. The orbit was designed to allow all data to be collected at approximately the same local time each day in every location.

The figure shows the configuration of the satellites; they are about 3 meters (10 feet) tall with a 2.6 meter (8.5 foot) solar panel span. The satellites weigh about 900 kg (one ton). The remote sensors on LANDSAT include a multispectral scanner (MSS) and a return beam vidicon (RBV) system. The scanner gathers spectral reflectance data about the earth's surface in four spectral bands, two in the visible portion of the spectrum and two in the near infrared. The return beam vidicon system consists of three television cameras which view the ground and collect data in three spectral bands, two in the visible range and one in the near infrared.

As each satellite passes over the earth, it collects continuous data from an area 185 kilometers (115 miles) wide. For ease of handling, the MSS data is divided into frames with dimensions of 185 by 185 km, which corresponds to the frame size of the RBV data. It takes just 25 seconds to collect the data in one frame. Each satellite is capable of collecting data 825 million sq km (320 million square miles) each week.

Another type of data is collected by LANDSAT. In the United States, some 150 unmanned data collection stations monitor local environmental conditions such as temperature, humidity, snow depth, soil moisture content, stream flow, water level of lakes and streams, ocean salinity and atmospheric pollution. Information from these earth-based sensing stations is relayed from the ground to the satellite where it is received through the data collection antenna.

The data collected by the satellites is transmitted to one of the ground receiving sites. After some processing by NASA, it is then made available to users through the data distribution centers.

LANDSAT data are being applied to many resource management problems, including agricultural crop surveys, land use mapping, geological studies of structures and rock types, mineral exploration, determining soil type and moisture content, assessing water resources including surface water distribution, surveying coastal and marine resources, collecting water pollution data, evaluating forest and range resources, and detecting air pollution.

Prepared by James D. Russell

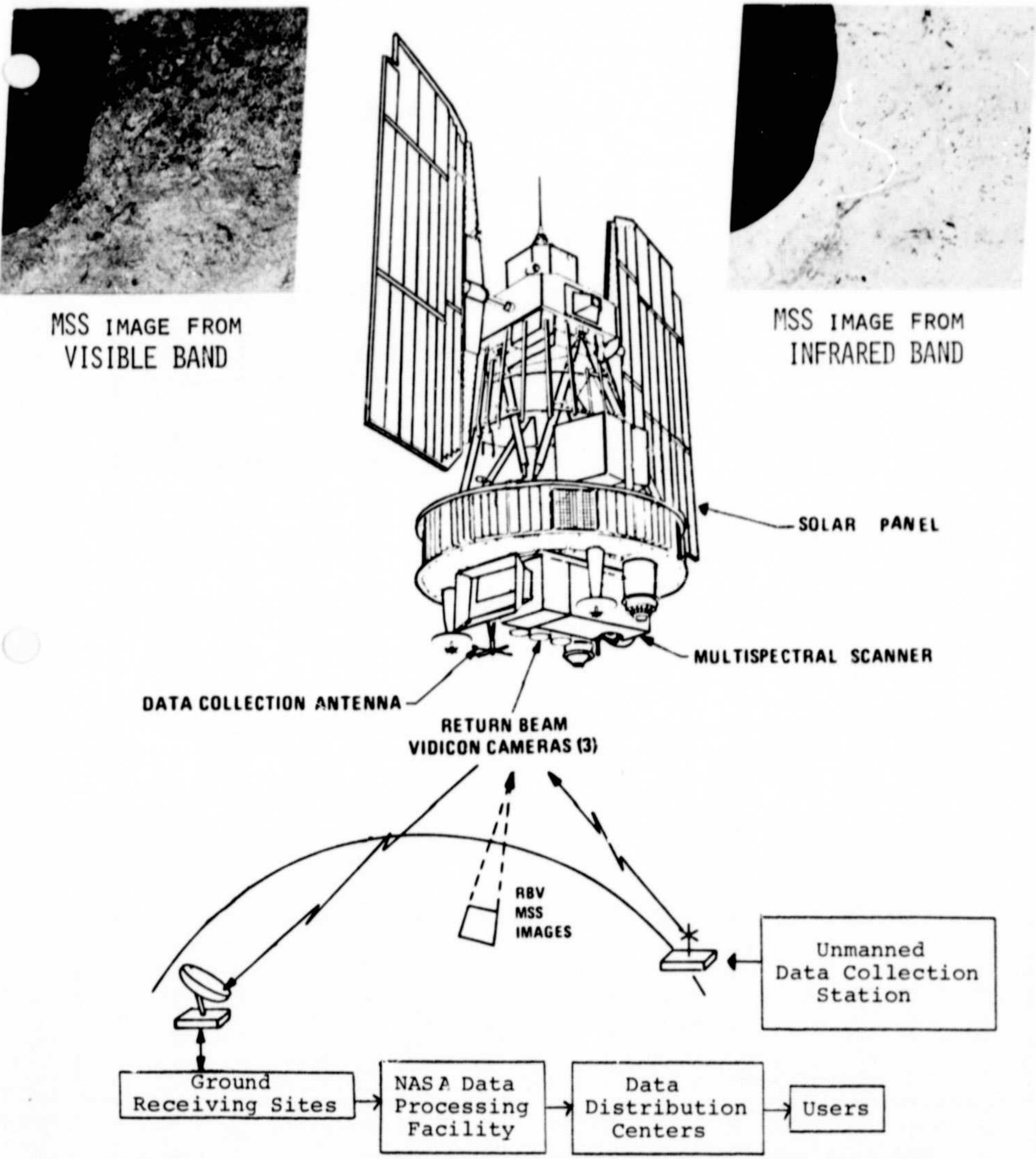
MSS IMAGE FROM VISIBLE BAND
MSS IMAGE FROM INFRARED BAND
SOLAR PANEL
MULTISPECTRAL SCANNER
DATA COLLECTION ANTENNA
RETURN BEAM VIDICON CAMERAS (3)
RBV MSS IMAGES
Unmanned Data Collection Station
Ground Receiving Sites
NASA Data Processing Facility
Data Distribution Centers
Users

Figure 1

FURTHER READING

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"ERTS-1: Toward Global Monitoring"
Astronautics and Aeronautics
September 1973

Earth Resources Technology Satellite-1
NASA Publication X-650-73-10, September 1972

Symposium on Significant Results Obtained from Earth Resources Technology Satellite-1
NASA Publication SP-327, March 1973

Third Earth Resources Technology Satellite-1 Symposium
NASA Publication SP-351, December 1973

Prepared by
The Laboratory for Applications of Remote Sensing
Purdue University, West Lafayette, Indiana 47907

S. M. Davis, General Editor

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LARS-Purdue

Role of Images in Numerical Data Analysis

Role of Images in Numerical Data Analysis

Remote sensing data is often collected in numerical rather than image form; for instance, measurements of ground radiation may be recorded on computer tape instead of photographic film. Numerical data is essential for many quantitative analysis methods but, during the analysis, the data analyst may wish to create images from the numerical data and thus have the measurements represented in a form that can be visualized. In numerical data analysis, the image may not be an essential part of the analysis process--as it is for photointerpretation--but it can often provide a convenient way for the analyst to assess data quality and monitor the analysis procedure.

Typically, three kinds of images may be produced during the analysis sequence: 1) the reconstructed image, derived from the unaltered data; 2) the enhanced image, an improvement of the reconstructed image or a representation of data which has been improved in some way; and 3) the classification image, representing the results of analyzing the data. These images may be produced in several forms: as computer printouts with alphanumeric symbols; as black-and-white or color images on a television-like screen; or as photographic images.

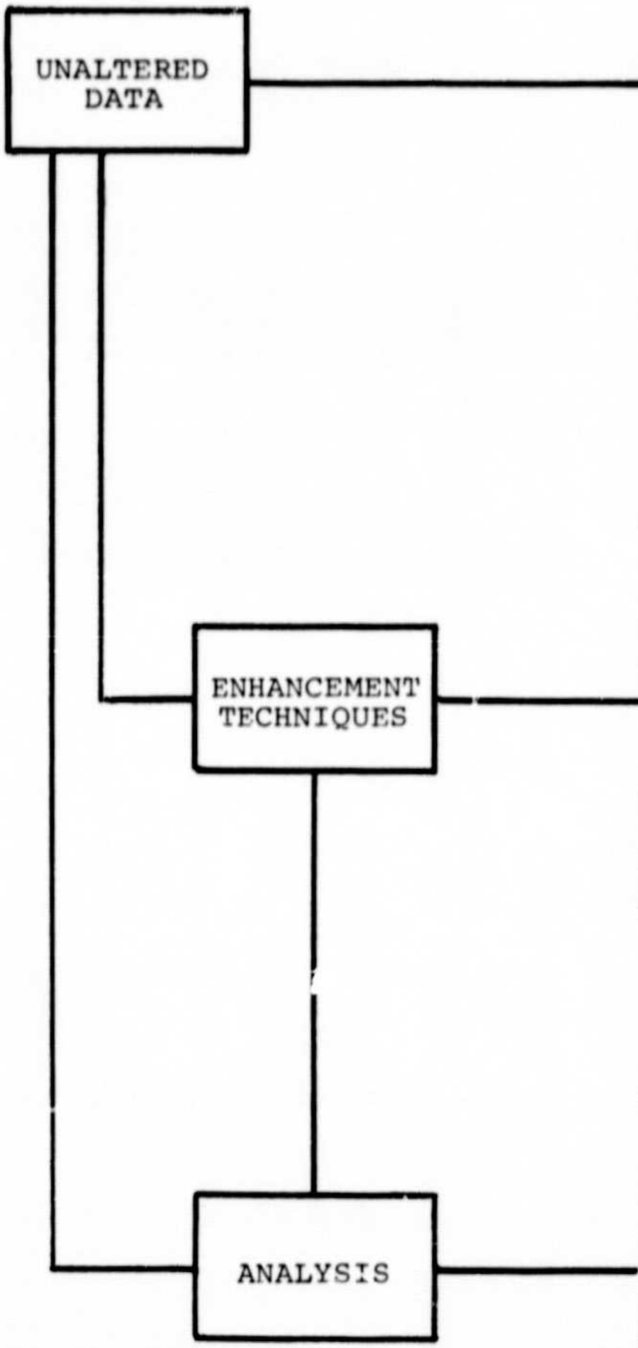
The reconstructed image (Figure 1) represents the radiation from the original ground scene; the process used to produce it is simply a reassembling process. Imagine that a picture of the ground has been cut into narrow strips and the strips have been spliced, end-to-end, into one long continuous strip. This is roughly analogous to the form in which the numerical data is stored on magnetic tape. It would be impossible to tell by inspecting the long strip what the original scene looked like, yet the image is still there--all of the information is retained. Furthermore, it is a fairly routine matter to reassemble the original image by electronic means. The process of reassembling these strips is analogous to reconstructing the image.

The enhanced image represents data that has been "improved" in some way. Figure 2 represents satellite data which has been corrected for geometric distortions inherent in LANDSAT data. Other numerical enhancement techniques include correcting for sun-angle effects and improving the contrast in the data. When data is enhanced photographically, it is sometimes displayed as a "synthetic" color image, which may emphasize selected ground features. To create a "synthetic" color image of a particular scene, a single frame of color film is exposed to three black-and-white images representing the data in different spectral bands, with a different color filter used for each exposure.

The third type of image is the classification image. If an analyst had classified data according to land use (i.e., urban, agricultural, forest, etc.) an image representing his results might display each class as a different symbol, a different color, or as shown in Figure 3, a different gray level.

The representation of numerical data in an image format is a useful tool for the data analyst. It provides him with a means of visually monitoring the analysis and presenting his results in an easily interpreted format.

Prepared by Leslie Wilson



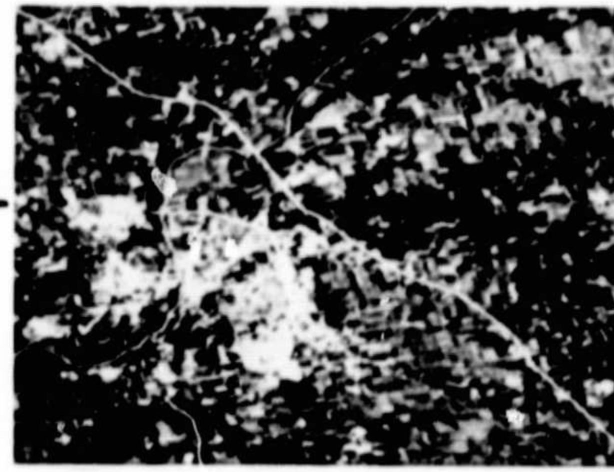


FIGURE 1
Reconstructed Image

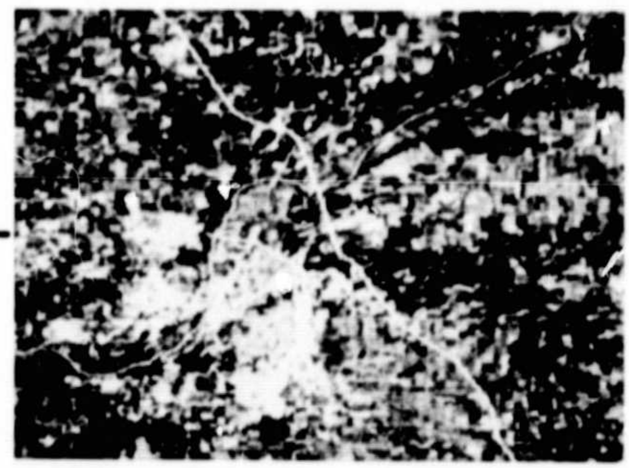


FIGURE 2
Enhanced Image

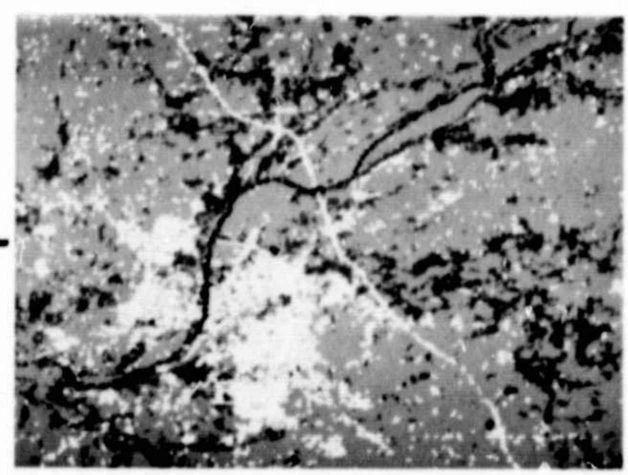


FIGURE 3
Classification Image

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Bulletin 12G125. 1974

D. A. Landgrebe
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Machine Processing Methods for Earth Observational Data
LARS Information Note 100773.
1973

P. H. Swain & Staff
Data Processing I: Advancements in Machine Analysis of Multispectral Data
LARS Information Note 012472.
1972

Prepared by
The Laboratory for Applications of Remote Sensing
Purdue University, West Lafayette. Indiana 47907

S. M. Davis, General Editor

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LARS - Purdue

Crop Species Identification

Crop Species Identification

Since each vegetative species reflects, transmits, and absorbs the sun's energy in characteristic ways, crop species identification is possible by remote sensing. For example, corn and soybean leaves of comparable moisture content reflect the incident solar energy distinctly enough to be differentiated spectrally (note the lower curves on Figure 1).

Color infrared photography has been widely used for crop species identification because of its sensitivity to energy in both the visible and near infrared regions of the spectrum; significant reflectance differences in these wavelength regions can frequently be used to distinguish between crop species. Crop species identification may be achieved with still greater accuracy by using data from multispectral scanner systems capable of providing more measurements over a wider spectral range.

If reflectance data are available from several dates during the growing season, some crops which are difficult to discriminate at any one time may be more readily identified. For example, in the fall a field of newly seeded winter wheat might be spectrally indistinguishable from bare soil; in May it might be indistinguishable from alfalfa. But if data are available from both dates, the fields of winter wheat can be identified since there is no other field type which is characteristically bare soil in late fall and green in May.

For any crop, the measured spectral reflectance is affected by many natural and cultural variables, such as moisture availability, planting and fertilization practices, climate, and soil type. Figure 1 shows the effect of leaf moisture content on the spectral reflectance of corn. Research in crop species identification is now being directed toward understanding how to compensate for these variables over large geographic areas.

Figure 2 is an example of crop species classification in a three-county region in northern Illinois. The goal of the analysis was to estimate the percentage of the area planted in corn and in soybeans. The data used was collected by the LANDSAT multispectral scanner during August 1972. The crop area percentages resulting from the analysis were consistent with those gathered in conventional surveys conducted by the United States Department of Agriculture.

In the United States and other developed countries, crop surveys have been conducted for many years and have become essential to wise management of agricultural resources. Traditionally these surveys have been conducted using subjective and often time-consuming sampling methods such as personal interviews, mailed questionnaires, and on-the-ground observations. Crop species identification by remote sensing offers an alternative to traditional survey methods and has the potential for greater accuracy, cost-effectiveness and timeliness.

Prepared by Shirley M. Davis

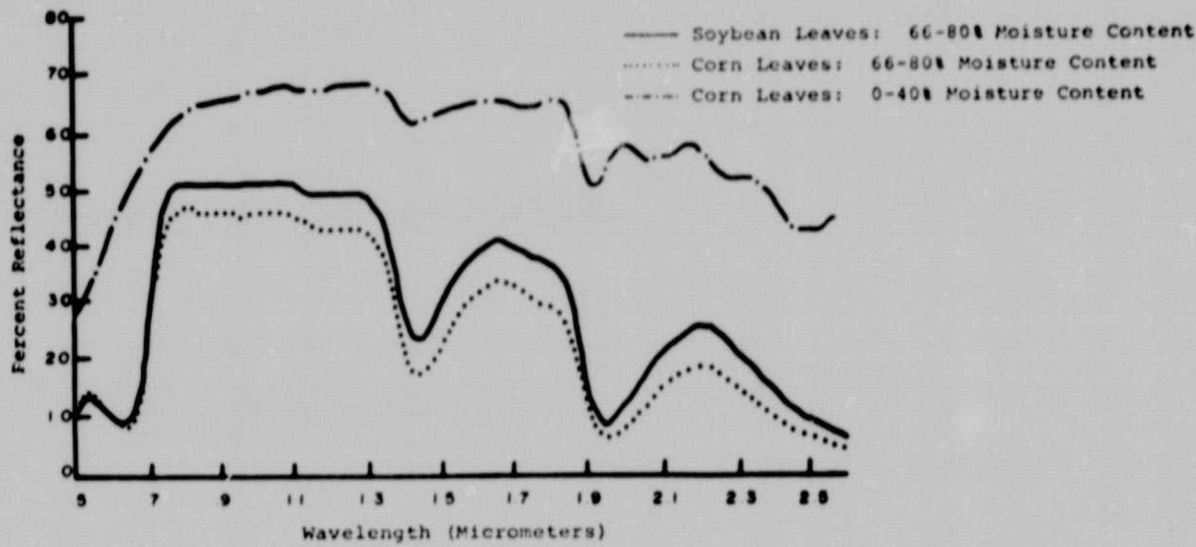

Figure 1. Reflectance curves for corn and soybean leaves

Figure 2. Computer classification map of corn, soybeans and "other." (Corn: black; soybeans: gray; "other" white.)

Comparison of USDA acreage estimates with estimates derived from computer analysis of LANDSAT data (Dekalb, Ogle, and Lee Counties, Illinois).

	USDA	LANDSAT
	(Percent of Total Area)	
Corn	40.2	39.6
Soybeans	18.0	17.8
"Other"	41.8	42.6

FURTHER READING

Marvin E. Bauer and Jan E. Cipra
Identification of Agricultural Crops by Computer Processing of ERTS MSS Data
LARS Information Note #30173. 1973

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National Academy of Sciences, Washington, D. C., 1970

Marvin E. Bauer
Role of Remote Sensing in Determining the Distribution and Yield of Crops
Advances in Agronomy
Academic Press, New York. 1975

Prepared by
The Laboratory for Applications of Remote Sensing
Purdue University, West Lafayette, Indiana 47907

S. M. Davis, General Editor

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LARS - Purdue

WHAT IS LARSYS?

What is LARSYS?

To many people in the remote sensing community, LARSYS is a software system -- an integrated set of computer programs -- for analyzing remote sensing data. But in fact, LARSYS is much more than that. LARSYS is an entire approach to the conversion of remote sensing data into information useful for monitoring and inventorying earth resources. Any adequate description of LARSYS would have to include the terms *multispectral, quantitative, pattern recognition,* and *computer-assisted.*

The LARSYS concept began to evolve in the mid-1960's. A group of scientists noted that aerial surveillance data from multispectral scanners could be used to discriminate among a wide range of earth cover types. Although it was still fairly early in the Space Age, they recognized the potential for using multispectral scanners aboard earth-orbiting satellites to gather earth resources data. They also recognized that the volume and rate of acquisition of data collected by such systems would be staggering -- as would the job of analyzing it! Furthermore, to produce the most useful results, the analysis process would have to be quantitative, operating on numerical data and producing numerical descriptions of the area surveyed. Clearly, this was a job requiring the data handling and computational abilities of computers.

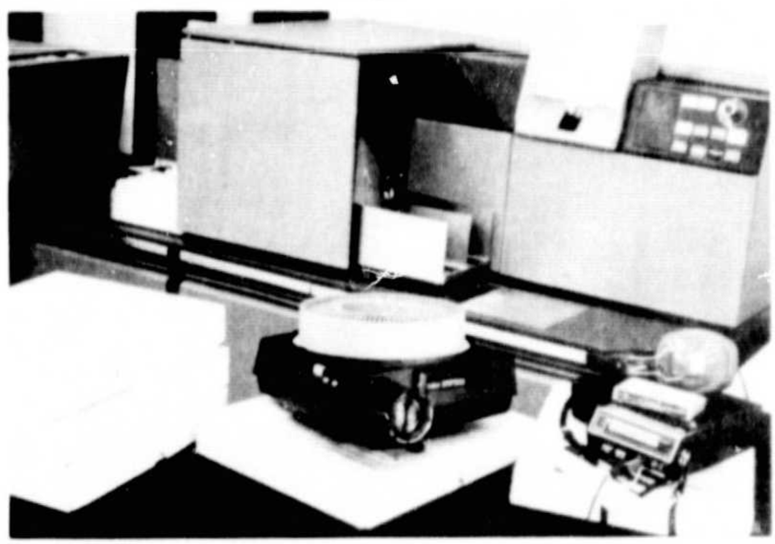
Thus, in 1966 the Laboratory for Applications of Remote Sensing (LARS) was organized at Purdue University with the goal of applying modern computer technology to the quantitative analysis of multispectral earth resources data. Two significant factors recognized early in this effort were (1) that an emerging data analysis technique known as "pattern recognition" represented a powerful methodology for accomodating the multivariate nature of the data, and (2) that for the foreseeable future, man was an indispensable part of the overall analysis process, which would therefore be better described as "computer-assisted" rather than "automatic."

LARSYS, then, is the approach which has evolved at LARS -- and continues to evolve -- from these basic ideas. It includes a software system (Figure 1) comprising a versatile package of data handling and analysis programs; a hardware system on which the software is implemented to provide the necessary interface between analyst and data; and an easily accessed library of multispectral earth resources data. Just as important, however, LARSYS includes comprehensive documentation of the data processing algorithms and their implementation as well as an educational package (Figure 2) through which the user can learn to apply this tool effectively. Finally, LARSYS includes the philosophy which continues to guide its evolution: optimal synthesis of man and computer, using the complementary capabilities of each, to produce rapidly the quantitative and accurate analysis results (Figure 3) needed in a wide range of earth resources applications.

Prepared by Philip H. Swain

Figure 1. Analysis processors of the LARSYS software system.

Figure 2. The multimedia LARSYS Educational Package.



Land Use	Number of Data Pts.	Number of Acres	Number of Hectares	% of Study Area
Cmrce/Indstry[1]	25766	28343	11479	8.2
Older Housing[1]	56528	621[illegible]1	25183	18.0
Newer Housing	28540	31394	12714	9.1
Wooded	52346	57581	23320	16.6
Agric/Grassy[1]	150982	166080	67262	48.0
Water	499	549	222	0.2
TOTAL	314661	346127	140181	100.0

[1] Adjustments made in accordance with test classification accuracy

Figure 3. Quantitative results produced by LARSYS.

FURTHER READING

T. Phillips and S. Schwingendorf
On the Access to an Earth Resources Data Processing System
LARS Information Note 031274. 1974

LARSYS User's Manual (Volume 1)
T. L. Phillips, ed. 1973

Prepared by
The Laboratory for Applications of Remote Sensing
Purdue University, West Lafayette, Indiana 47907

S. M. Davis, General Editor

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